

STATE CLASSIFICATION FOR AUDIO ACCESSORIES, AND RELATED SYSTEMS AND METHODS

FIELD

[0001] This application and related subject matter (collectively referred to as the “disclosure”) generally concern state classification for audio accessories, such as, for example, earphones, as well as related systems and methods. More particularly, but not exclusively, this disclosure pertains to wear state of an earphone.

BACKGROUND INFORMATION

[0002] Media devices can communicate an audio signal to one or more audio accessories during audio playback. For example, a media device can communicate audio to one or more in-ear, on-ear, or over-the-ear earphones to be worn by a user during playback. Perceived sound quality and other measures of performance for such an earphone can vary in correspondence with how well the earphone fits a particular user’s ear or head anatomy. For example, perceived sound quality can deteriorate if an in-ear earphone is not well-seated in a user’s ear canal, or if an on-ear or an over-the-ear earphone allows sound to leak past an ear-cup boundary. Similarly, a well-fitting earphone may be subjectively more comfortable to a user than an ill-fitting earphone.

[0003] “Fit,” in general, can correspond to one or more of, for example, a position, an orientation, and a shape of an earphone relative to a user’s anatomy. For example, an ear tip for an in-ear earphone that provides a substantially uniform pressure to a surface of a wearer’s ear canal can provide perceptually better sound and subjective comfort compared to an ear tip that impinges on one region of a wearer’s ear canal while barely urging against or contacting another region.

SUMMARY

[0004] According to an aspect, an earphone can determine whether a user is wearing the earphone, as by assessing a frequency response observed by the earphone.

[0005] According to another aspect, an earphone includes a housing and a corresponding user-contact surface configured to urge against a user’s anatomy. The housing defines an acoustic chamber and an acoustic port opening from the acoustic chamber. The user-contact surface is so complementarily configured relative to the user’s anatomy as to form an acoustic seal between the user-contact surface and the user’s anatomy, acoustically coupling the acoustic chamber with the user’s ear canal, when the earphone is donned. The earphone also has an acoustic driver positioned in the housing. The acoustic driver acoustically couples with the acoustic chamber. As well, a microphone transducer acoustically couples with the acoustic port. A processing component is configured to detect anti-resonance in sound observed by the microphone transducer across a selected spectral envelope spanning or above the upper threshold of human hearing.

[0006] The processing component can be configured to affect operation of the earphone responsive to detection of anti-resonance in the spectral envelope.

[0007] The processing component can be configured to cause the acoustic driver to emit sound in the spectral

envelope and to cause the microphone transducer to observe sound in the spectral envelope.

[0008] The spectral envelope can have a lower frequency threshold of about 20 kHz and an upper frequency threshold of about 24 kHz.

[0009] The processing component can be configured to assess a frequency response across the spectral envelope and to identify a presence of a notch in the frequency response.

[0010] The processing component can be configured to classify the earphone as being donned when anti-resonance is detected. The processing component can also be configured to classify a quality of the acoustic seal between the user-contact surface and the user’s anatomy based at least in part on the frequency response across the spectral envelope.

[0011] The earphone can also include an ear-tip defining the user-contact surface. The user’s anatomy can be an inner surface of the user’s ear canal, and the user-contact surface can be configured to urge against the inner surface of the wearer’s ear canal and form the acoustic seal.

[0012] According to another aspect, an earphone includes a housing, a loudspeaker transducer and a microphone transducer positioned in the housing. The earphone also has a processor and a memory containing instructions that, when executed by the processor, cause the earphone to assess sound observed by the microphone within a frequency band having a lower threshold of about 20 kHz and an upper threshold of about 24 kHz. Based on the assessment, the instructions, when executed, can also cause the earphone to determine when the earphone is donned by a user.

[0013] The assessment of sound can include an assessment of a frequency response within the frequency band. The instructions, when executed by the processor, can further cause the earphone to identify a presence or an absence of anti-resonance within the frequency band from the assessment of the frequency response. The instructions, when executed by the processor, can also cause the earphone to classify a quality of fit between the earphone and a corresponding region of a user’s anatomy.

[0014] The earphone can include an in-ear ear-tip defining a corresponding user-contact surface configured to urge against a wall of a user’s ear canal and form an acoustic seal between the in-ear ear-tip and the user’s ear canal. The housing can define an acoustic chamber and the in-ear ear-tip can define an acoustic port opening from the acoustic chamber. The acoustic port can be configured to acoustically couple the acoustic chamber with the user’s ear canal when the in-ear ear-tip is inserted into the user’s ear canal.

[0015] When the instructions are executed, the earphone can classify a quality of the acoustic seal between the in-ear ear-tip and the user’s ear canal.

[0016] According to yet another aspect, methods for controlling operation of an earphone are described. For example, the earphone can house a microphone transducer and an acoustic driver. According to the method, sound is emitted across a spectral envelope with the acoustic driver. Sound observed by the microphone is assessed within the spectral envelope. The spectral envelope has a lower threshold of about 20 kHz and an upper threshold of about 24 kHz. When the earphone is donned by a user is determined based on the sound assessment.

[0017] The act of assessing sound within the spectral envelope can include determining a presence or an absence of anti-resonance within the spectral envelope.